Non-Conventional Sintered

Aluminium Powder Alloys

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Statement of Originality

To the best of my knowledge, the material presented in this thesis is original, except where otherwise noted in the text. None of this research has been submitted in whole, or part, for any degree at this, or any other university.

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Abstract

The aim of this thesis was to improve the properties of pressed and sintered aluminium powder alloys. This improvement was to be achieved using two methods. The first method involved the selection of an alloy system using binary aluminium phase diagrams and a knowledge of the phase diagram characteristics of ideal sintering systems. The second approach involved the judicious use of selected trace element additions to modify the sintering characteristics of aluminium and its alloys.

A trace amount of magnesium was found to be critical to the sintering of aluminium powder due to its disrupting effect on the tenacious oxide layer covering the powder particles. The critical amount of Mg required to optimise both density and mechanical properties is dependent on the specific volume of oxide and the therefore particle size. The optimum concentration is 0.1-1.0wt% Mg.

The Al-Sn phase diagram exhibits many of the characteristics of an ideal sintering system. Unsurprisingly, Sn was found to be an extremely efficient sintering aid, but only in the presence of Mg. Near full density parts were produced using an Al-8Sn-0.15Mg alloy in short sintering times (30 minutes). Additionally, as-sintered ductilities exceeding 20% were achieved using an Al-2Sn-0.15Mg alloy. Alloys based on the Al-Sn-Mg system lend themselves to sintering without compaction and therefore freeformed Al-Sn-Mg alloys have been produced and sintered to near full density from a starting density of ~50%.

Trace amounts of Sn (Pb, In, Bi, or Sb) enhance the sintering response of an Al-4Cu-0.15Mg alloy via a vacancy binding mechanism. A similar mechanism suppresses natural ageing and stimulates artificial ageing when trace amounts of Sn are added to this alloy. A Sn-modified 2XXX series alloy has also been produced with mechanical properties nearly 20% above current commercial alloys. Along with the addition of 0.1wt%Sn, this improvement required an alteration to the solution treatment cycle which allowed the use of a higher sintering temperature without the formation of large amounts of boundary phase.

List of Associated Publications

T.B. Sercombe and G.B. Shaffer, "Sintering of a Non-Conventional Aluminium Powder Alloy", Advances in Powder Metallurgy and Particulate Materials - 1997, R.McKotch and R.Webb Eds., Proceedings of the 1997 Conference on Powder Metallurgy and Particulate Materials, Chicago, IL, 29 June -2 July 1997.

Lumley, T.B. Sercombe, and G.B. Schaffer, “Surface Oxide and the Role of Magnesium During the Sintering of Aluminium”, Metallurgical and Materials Transactions A, in press.

Sercombe, G.B. Schaffer and P. Calvert, "Freeform Fabrication of Functional Aluminium Prototypes Using Powder Metallurgy", Journal Of Materials Science, submitted February 1998.

Sercombe and G.B. Schaffer, "The Effect of Trace Elements on the Sintering of Al-Cu Alloys", Acta Metallurgica, in press.

Sercombe and G.B. Schaffer, "On the use of trace additions of Sn to enhance sintered 2xxx series Al powder alloys", International Journal of Powder Metallurgy, in preparation.

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